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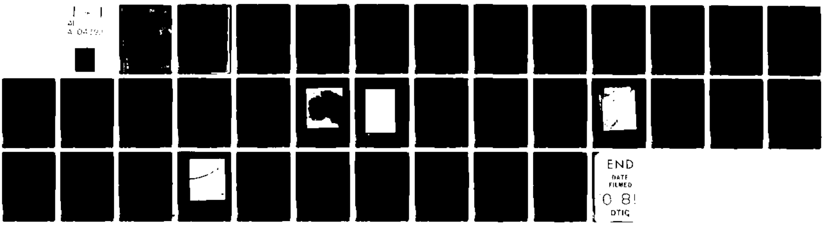

LEVEL II

AD A104392

AFGL-TR-81-0105

THE USE OF DMSP DIGITAL DATA FOR AURORAL MEASUREMENTS

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15 February 1981

Final Report for Period 15 January 1979 - 15 January 1981

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PREPARED FOR

AIR FORCE GEOPHYSICS LABORATORY
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Using measurements of aurora made by ground and aircraft based photometers and correlated in space and time with DMSP observations, two DMSP night time sensors have been calibrated. A procedure has been developed for computer reduction and analysis of the calibrated DMSP digital tape data.

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FOREWORD

The effort discussed in this report concerns measurements of auroral intensities and spatial variations using satellite, aircraft, and ground-based sensors. Primary emphasis has been on calibration of night time sensors on two DMSP satellites, and on development of computer techniques for handling the DMSP digital tape data.

The author wishes to thank R. Nadile (AFGL/OPR), technical monitor, for his encouragement and support. We also wish to thank J. Bass (Logicon) and H. Fish (RDP) for their efforts in development of the computer programs, and R. Sears, (Lockheed Missiles and Space Corp.) for providing ground station data.

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1. INTRODUCTION

The Defense Meteorological Satellite Program (DMSP) has been providing unclassified meteorological imagery to the scientific community since early 1973. The forerunner to DMSP was the classified Defense System Applications Program (DSAP) which provided so-called DAPP (Data Acquisition and Processing Program) data.

Our effort has concentrated upon development of a data analysis system which will allow optimal use of DMSP auroral and airglow imagery for a variety of applications. The current version of DMSP, known as Block 5D, became operational in late 1975 with the launch of the F1 satellite. Since that time, three additional satellites were launched successfully and one unsuccessfully, with approximately three more planned before a possible integration into the shuttle program.

Our program has included calibration of the night time visible sensors on the F1 and F2 satellites in the Block 5D series. By correlating auroral intensities measured by ground and airborne photometers with the DMSP observation simultaneous in space and time, the night sensors on these two satellites have been calibrated in terms of effective auroral intensity. The approach to this calibration is unique, to our knowledge, since earlier approaches have used DMSP auroral data taken from photographic transparencies. The current approach uses the digital telemetry information from which the transparencies are produced. This digital data has been supplied by AFGWC.

Access to digital data on magnetic tape has allowed straightforward development of computer approaches to data handling. The effort has been to develop a flexible system which allows manipulation of the data dependent upon the specific application and presentation in a variety of formats.

The program has also included correlation of auroral observations from the calibrated DMSP F2 satellite with data taken by an uncalibrated satellite.

2. CHARACTERISTICS OF THE DMSP BLOCK 5D SERIES

The primary sensor on the DMSP satellite provides visual and infrared imagery of the earth on a continual basis, with the primary mission to provide meteorological data. In addition to the primary sensor there are a variety of smaller sensor packages. These generally have included the SSJ electron spectrometer and the SSIE plasma monitor.

To date, our program has used only data from the primary visible sensor on the DMSP. Table 2-1 lists some of the characteristics of the night time visible sensor. The orbital characteristics of the satellite are also given.

In order to perform its primary mission of providing timely and accurate meteorological data for the U.S. military on a global basis, the DMSP has been placed in a polar orbit at an inclination of 98.7° with respect to the equator. The design orbital altitude is 450 nautical miles (833 km), yielding an orbit period of 101 minutes.

The total data system for the primary sensor on the Block 5D DMSP is called the OLS (Operational Linear System). The OLS contains a number of changes from the 5 B/C series which yield improved system performance in terms of spatial resolution and accuracy.

The requirement for global meteorological data requires that the OLS optical system performs a scan which will yield continuous data when outputs from successive orbits are placed side-by-side. To do this, the optics scan a full angle of 112.5° in a direction perpendicular to the subsatellite track. This scan corresponds to a geocentric scan angle of 27.5°, yielding a scan on the earth's surface of 1655 nautical miles (3065 km). The 101 minute orbital period corresponds to an earth rotation of 25.4° under the satellite during each orbit. Thus, successive orbits yield scans which overlap slightly the scans of the previous orbit.

The orbital parameters of the satellite were configured to place it in a sun synchronous orbit, so that local time at the satellite is essentially constant for a given subsatellite latitude on each pass.

Table 2-1. Characteristics of DMSP Block 5D Night Sensor

DMSP BLOCK 5D (NIGHT)

ORBIT CHARACTERISTICS:

-- 450 NMI (833 km)

-- 101 Minutes/Revolution

-- 98.7° Inclination

-- 81.3° North & South Max Lat. Subpoint

SCAN CHARACTERISTICS:

-- 112.5° Full Angle
(27.5° Geocentric)
(1655 NMI)

-- 1.5 NMI (2.8 km) Ground Resolution (nom.)
(Derived from 11.88 scan /Sec rate and 5 Scan Average with 8 KHz on-board filter)
(Compensated FOV to yield nearly constant footprint)

-- 1464 Resolution elements/scan

ELECTRICAL CHARACTERISTICS:

-- Lin and Log Sensitivities

-- Dynamic Range = 100 on Log
= 64 on Lin

-- Ground Programmable Gain (Saturation Value)
In finer than 1 db steps from 1 - 63.875 db
(DB = 20 Log V (Out)/V (In)

-- S/N Better than 6 at 8E-09 watts per cm sq per ster.

In the 5D series, F1 had equatorial crossings at approximately noon-midnight, providing excellent night-side auroral views. F2, F3, and F4 were morning-evening satellites with equatorial crossings in the 8 - 10 AM-PM time region.

A major change in the night time sensor for 5D compared to 5 B/C was the shift to a photomultiplier as the detector from the silicon detector previously used. Silicon remains as the daytime sensor. Figure 2-1 shows the relative sensitivity curves for the photomultipliers used in F2 and F4. The response of the PMT's in F1 and F3 were quite similar to F2. The shift to red enhancement occurred in F4.

In addition to the day/night visual channel, the DMSP records simultaneous data in the infrared. In the F1 to F4 flights this channel was sensitive to thermal radiation in the 8 - 13 micron infrared band. The detector is HgCdTe cooled to approximately 108 K. To date, we have made only slight use of the infrared data. There is, as yet, no evidence of auroral effects being observable in this channel.

The design of the OLS improved considerably the uniformity of the system geometric resolution over the 5 B/C series. The system is now required to have a resolution of 0.3 nautical miles for daytime viewing and 1.5 nmi for night imagery. The actual night resolution varies from approximately 1.2 nmi (2.2 km) at nadir to somewhat more than 1.5 nmi (2.8 km) at the ends of the scan.

The OLS uses an optical scanning technique combined with shaped detector surfaces to achieve its uniform spatial resolution, compared to the 5B/C series. The OLS rotates and switches the detector field of view to maintain image uniformity. This is combined with electrical gain switching along the scan to yield the desired scene sensitivity.

Overall sensitivity of the night time channel is controllable from the ground over a range of 63-7/8 db in 1/8 db steps. In addition, one may select either a logarithmic or linear response in the amplifier. (For our purposes, 20 db = factor of 10 in input signal level.)

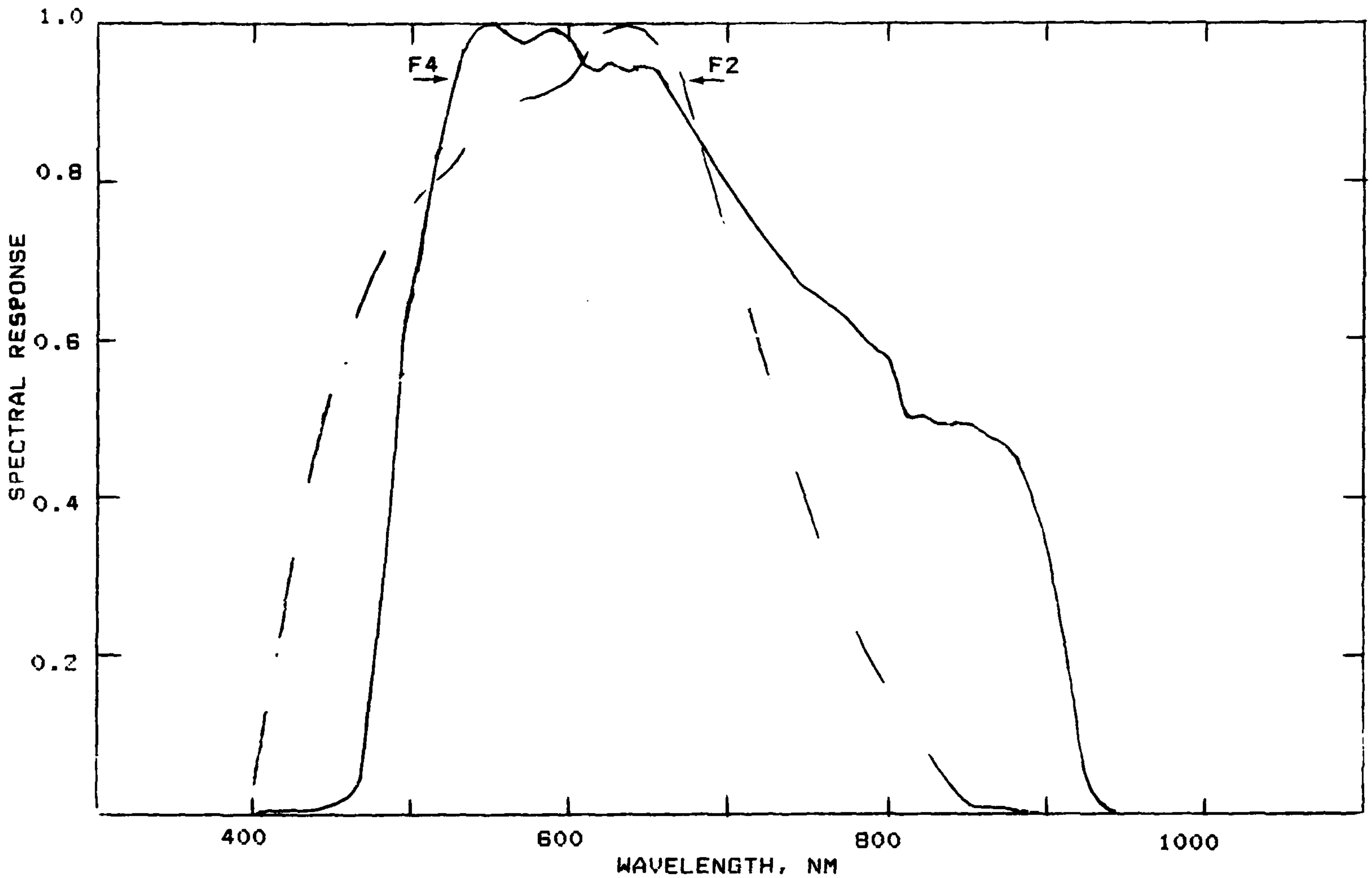

Figure 2-1. Relative Response of DMSP PhotoMultipliers.

Data is processed and digitized on board the satellite. The basic scan rate of the sensor system was configured to give continuous earth coverage when combining the subsatellite track velocity with the field-of-view of the sensor system. Since the subsatellite track velocity for the orbital parameters given earlier is 3.55 nmi per second, the required scan rate corresponding to the daytime 0.3 nmi resolution is 11.88 scans per second for continuous coverage. The onboard processing averages over five successive scans to yield the so-called "smoothed" daytime resolution of 1.5 nmi and the fixed night time 1.5 nmi resolution.

The smoothed data is filtered and digitized to yield 1464 pixels of data for each effective scan (average of five). The data is digitized with 5 bit resolution yielding a scene instantaneous dynamic range of 64 using the linear amplifier and a dynamic range of 100 using the log amplifier. The gain of the overall system can be changed over the 64 db range mentioned earlier to yield a total dynamic range of over 10^5.

3. EXPERIMENTAL PROGRAM

The calibration effort has involved a number of simultaneous or near simultaneous spatial-temporal correlations between various DMSP Block 5D satellites and aircraft and ground stations viewing auroral situations. This included the use of satellite ephemeris predictions generated by AFGL/SUA and projected flight plans of the AFGL/OP NKC-135 (SN 53120) Flying Laboratory. An example of printed ephemeris data is shown in Fig 3-1. In those missions that involved ground measurements, plans were coordinated with the Lockheed group (R. Sears).

DMSP data has been supplied by AFGWC in two different forms during the period of this program. Early in the program, digital data for the specified satellite, revolution and time period was supplied as an octal dump on paper of pixel information by scan line. Figure 3-2 is an example of few scan lines of information. Each line contains 1464 pairs of octal numbers which represent 8^2 levels of signal information for each pixel. In addition, there is time code, gain, and other housekeeping information in each scan line. The data format will be discussed in more detail in Section 4.

Later in the program (after February 1979), the data requested from AFGWC was supplied on digital magnetic tape in a format compatible with the AFGL CDC computer.

Table 3-1 is a tabulation of digital data supplied by AFGWC through February 1980. The table identifies the data, satellite, revolution number, and universal time for which data exists. It also lists whether the data exists on binary magnetic tape or as paper printout. The revolution number is considered redundant information. The date, time and satellite identification are the primary data identifiers.

3.1. Calibration of F1

During the period January 1979 through early February 1979 the Lockheed optical research site at Chatanika, Alaska was in operation.

PREPARED BY/FOR THE ANALYSIS AND SIMULATION BRANCH (SUA), AIR FORCE GEOPHYSICS LABORATORY, TELEPHONE 861-4161

STATION NO.	MO DY YR	UNIVERSAL TIME DAY	HR	MIN	SEC	ELEV DEG	AZIM DEG	RANGE KM	ALT KM	RT ASC DEG	DECL DEG	SUB-SATELLITE LAT DEG	SUB-SATELLITE LONG DEG	SUN ELEV DEG	SAT ILLUM DEG	REV NO.
9	1/28/79	28	4	58	0	15.38	63.92	2153.	871.74	147.83	22.27	65.46	105.98	-24.32	-11.17	8418
9	1/28/79	28	4	59	0	19.59	82.79	2144.	872.19	158.49	17.28	82.17	117.12	-24.42	-12.48	8418
9	1/28/79	28	6	36	0	16.17	31.50	2099.	868.43	213.84	36.89	76.37	110.53	-34.16	-5.36	8419
9	1/28/79	28	6	37	0	22.97	35.54	1761.	869.67	203.82	41.67	73.99	117.23	-34.29	-7.13	8419
9	1/28/79	28	6	38	0	31.45	46.18	1463.	870.67	189.31	46.19	70.57	125.46	-34.34	-8.78	8419
9	1/28/79	28	6	39	0	41.13	62.98	1234.	871.44	184.23	47.78	67.41	133.10	-34.43	-10.30	8419
9	1/28/79	28	6	40	0	48.07	91.55	1121.	872.00	135.38	41.81	64.16	137.70	-34.53	-11.69	8419
9	1/28/79	28	6	41	0	45.64	124.65	1157.	872.37	117.72	28.69	60.65	134.59	-34.62	-12.91	8419
9	1/28/79	28	6	42	0	36.62	147.59	1331.	872.57	98.54	14.80	57.50	139.98	-34.71	-13.97	8419
9	1/28/79	28	6	43	0	27.32	163.41	1597.	872.62	89.73	3.63	54.13	141.81	-34.80	-14.89	8419
9	1/28/79	28	6	44	0	19.62	168.04	1917.	872.53	83.90	-4.78	50.73	143.76	-34.89	-15.54	8419
9	1/28/79	28	8	17	0	20.50	15.81	1867.	867.69	254.82	44.12	77.08	123.92	-41.98	-4.23	8420
9	1/28/79	28	8	18	0	29.21	10.52	1528.	869.83	265.48	53.46	75.31	133.74	-42.03	-6.06	8420
9	1/28/79	28	8	19	0	40.84	.23	1235.	870.17	[illegible]	69.71	72.42	147.33	-42.09	-7.70	8420
9	1/28/79	28	8	20	0	54.21	336.85	1842.	871.07	336.18	74.18	69.34	152.84	-42.15	-9.34	8420
9	1/28/79	28	8	21	0	58.66	298.71	999.	871.79	28.40	58.43	66.14	157.92	-42.21	-10.89	8420
9	1/28/79	28	8	22	0	47.66	255.38	1125.	872.23	42.69	36.73	62.86	153.31	-42.26	-12.17	8420
9	1/28/79	28	8	23	0	34.70	244.31	1377.	872.52	49.81	20.09	59.53	161.98	-42.32	-13.34	8420
9	1/28/79	28	8	24	0	24.65	232.80	1697.	872.65	58.61	8.41	56.17	155.21	-42.37	-14.33	8420
9	1/28/79	28	8	25	0	17.12	225.65	2051.	872.64	[illegible]	.02	52.79	157.13	-42.43	-15.14	8420
9	1/28/79	28	9	57	0	15.55	11.71	2130.	865.85	286.25	39.75	80.56	125.87	-45.16	-1.08	8421
9	1/28/79	28	9	58	0	20.15	1.45	1984.	866.90	299.32	44.99	79.14	145.57	-45.10	-3.00	8421
9	1/28/79	28	9	59	0	24.16	347.79	1703.	868.31	318.34	48.27	76.90	153.87	-45.18	-4.95	8421
9	1/28/79	28	10	0	0	26.36	331.09	1627.	869.59	341.26	47.09	74.20	159.44	-45.10	-6.74	8421
9	1/28/79	28	10	1	0	25.68	313.58	1654.	870.62	1.78	40.86	71.22	173.10	-45.10	-8.41	8421
9	1/28/79	28	10	2	0	22.52	296.15	1743.	871.43	15.19	32.03	68.09	180.82	-45.10	-9.90	8421
9	1/28/79	28	10	3	0	18.15	286.14	1996.	872.03	25.69	23.14	64.85	187.81	-45.10	-11.38	8421
9	1/28/79	28	11	38	0	16.38	4.86	2079.	863.99	320.11	41.11	80.85	130.99	-42.31	.17	8422
9	1/28/79	28	11	39	0	17.35	351.34	2027.	865.86	337.05	41.84	80.12	150.26	-42.25	-1.85	8422
9	1/28/79	28	11	40	0	16.77	336.68	2063.	867.51	353.05	39.53	78.33	175.09	-42.20	-3.00	8422
9	1/28/79	28	13	16	0	15.78	37.58	2098.	855.75	305.51	34.57	74.56	107.72	-34.97	8.65	8423
9	1/28/79	28	13	17	0	17.73	24.83	1992.	858.27	319.70	39.70	77.21	117.92	-34.87	5.00	8423
9	1/28/79	28	13	18	0	18.17	11.16	1974.	860.65	336.95	42.42	79.36	131.64	-34.78	3.59	8423
9	1/28/79	28	13	19	0	16.95	357.83	2064.	862.85	354.33	41.77	80.60	151.97	-34.69	1.49	8423
9	1/28/79	28	14	54	0	19.93	82.29	1856.	846.65	283.67	21.19	63.23	115.22	-25.22	16.54	8424
9	1/28/79	28	14	55	0	25.22	69.35	1635.	848.84	292.92	31.27	66.51	119.60	-25.12	14.15	8424
9	1/28/79	28	14	56	0	29.21	52.38	1581.	851.59	307.05	41.68	69.71	122.92	-25.01	11.78	8424
9	1/28/79	28	14	57	0	29.99	32.43	1491.	854.28	330.87	49.53	72.78	127.69	-24.91	9.48	8424
9	1/28/79	28	14	58	0	27.12	13.98	1573.	856.87	356.59	50.97	75.64	135.57	-24.80	7.17	8424
9	1/28/79	28	14	59	0	22.22	359.59	1775.	859.34	17.75	47.07	78.14	147.98	-24.70	4.94	8424
9	1/28/79	28	15	0	0	16.96	349.42	2041.	861.64	30.46	41.27	80.00	164.08	-24.59	2.76	8424
9	1/28/79	28	16	32	0	15.98	148.96	2054.	836.84	254.60	-4.59	51.83	137.58	-15.00	25.36	8425
9	1/28/79	28	16	33	0	23.59	142.89	1682.	838.86	254.61	3.32	54.45	134.37	-14.90	22.90	8425
9	1/28/79	28	16	34	0	34.39	138.37	1349.	841.08	254.96	14.58	57.89	134.45	-14.79	20.49	8425
9	1/28/79	28	16	35	0	50.22	130.26	1057.	844.47	255.71	31.52	61.21	135.89	-14.69	18.02	8425
9	1/28/79	28	16	36	0	70.08	97.32	894.	847.27	258.81	58.48	64.53	137.88	-14.59	15.60	8425
9	1/28/79	28	16	37	0	66.46	14.12	917.	850.05	291.73	84.67	67.79	148.57	-14.49	13.22	8425
9	1/28/79	28	16	38	0	46.84	350.91	1114.	852.78	60.97	71.07	70.94	159.38	-14.39	10.87	8425
9	1/28/79	28	16	39	0	32.36	346.15	1414.	855.43	66.03	55.82	73.94	155.86	-14.29	8.56	8425
9	1/28/79	28	16	40	0	22.44	341.12	1763.	857.97	67.31	45.98	76.60	159.90	-14.19	6.30	8425
9	1/28/79	28	16	41	0	15.26	338.47	2138.	860.37	67.77	38.13	78.97	173.85	-14.09	4.08	8425

Figure 3-1. DMSP Ephemeris Data.

RECORD NUMBER 107 WORD COUNT 1120

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16	534444305041	334441344222	375544354556	443342333362	424755414034	365150373541	414253424735	404145564646
24	474141442647	464244274252	404054443626	343761463332	364434534730	335042364341	353251433346	423741415050
32	373540443622	445637414546	363040353251	374636264547	343742435444	415257434236	344137453237	464537514240
40	464142433246	434041433543	514650504650	333043545150	424653453047	514044504756	555442414435	505243543440
48	465141405241	564436374243	315251424345	374251504644	373145523220	423123312126	342641452426	403437302741
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72	143057503343	343141374036	353132343132	252542474037	314240555435	273731434437	223444333143	562333464441
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200	313225333433	412622232541	503550413225	243533422136	463635763430	463335252732	372316345342	144043312525
208	253033514632	344445170631	323140401431	442233433142	503630773140	373434373230	363540413647	373340334134
216	352627464345	453727750433	132242463442	514526364025	263140373231	213132314041	372736353625	254541313315
224	163043303033	172333272424	262544352116	223737254336	263222203644	253047271141	313732335233	302733412724
232	272427274650	354747314150	452735413633	313415112136	364026353720	253746453625	302043343235	252227403234
240	333104254736	252641314151	272413202622	061125341620	313031503113	313131262730	233627343335	002230751753
248	770340576360	000407722321	400001000703	400077370174	464756515141	334435325031	325044375757	434241424046

Figure 3-2. Dump of DMSP Digital Data(Octal)

Table 3-1. Digital Data Supplied by AFGWC

Date	Satellite	Rev. #	Time (U.T.)	Type of Data
9/2/78	F1	10221	11:05-11:10	Paper
10/25/78	F1	10972	10:30-10:56	Paper
10/31/78	F1	11057	10:24-10:53	Paper
11/1/78	F1	11071	10:06-10:22	Paper
11/2/78	F1	11085	9:45-10:09	Paper
1/29/79	F2	8547	7:20- 7:28	Paper
2/2/79	F2	8604	7:52- 7:57	Paper
2/3/79	F2	8618	7:35- 7:41	Paper
2/4/79	F2	8648	7:07- 7:12	Paper
2/5/79	F1	12432	10:11-10:20	Paper/Mag
2/6/79	F1	12446	9:54-10:00	Paper
4/18/79	F4	1466	1:54- 2:06	Mag
4/25/79	F1	13549	4:58- 5:02	Mag
4/27/79	F4	1594	2:30- 2:34	Mag
9/27/79	F2	11960	1:54- 1:58	Mag
9/27.79	F2	11961	3:35- 3:39	Mag
12/15/79	F2	13091	20:10-20:17	Mag
12/24/79	F2	13219	20:49-20:55	Mag
1/11/80	F2	13474	20:25-20:31	Mag
1/13/80	F2	13502	20:49-20:53	Mag
1/14/80	F2	13516	20:31-20:37	Mag
1/15/80	F2	13530	20:13-20:19	Mag
1/15/80	F2	13531	20:54-20:61	Mag
1/20/80	F2	13602	20:02-20:09	Mag
2/6/80	F2	13842	20:14-20:20	Mag
2/7/80	F2	13857	20:37-20:43	Mag
2/15/80	F2	13871	20:32-20:39	Mag

This site includes a three channel meridian scanning photometer as one of its primary instruments. The photometer channels are designed to measure 427.8, 557.7, and 630 nm radiation with a field-of-view of 3°. The instrument scans 80° each side of zenith at a rate of two degrees/second. Data is taken in 4° increments.

Figure 3-3 shows the approximate subsatellite track for Revolution 12432 (5 February, 1979) projected onto the Alaska map. Shown is the approximate ground track of the Lockheed photometer intersection at auroral altitudes. Figure 3-4 is a reproduction of the DMSP transparency generated from night time sensor data for the portion of Rev 12432 over Alaska. The location of Fairbanks is circled and the intersection of the three-color meridian scanning photometer with a surface at approximately 100 km is shown. The square envelopes Anchorage.

The DMSP F1 sensor during the portion of the orbit over Alaska was operating in linear mode with gain equal to 25 db. Table 3-2 tabulates a portion of the meridian scanning photometer data and the DMSP output when viewing the same region. It can be seen that time coincidence of the spatial scans occurred at approximately 72 km south of Chatanika during this scan (10 hr 58 min. UT). Averaging the two values nearest this coincidence yields an output of 58.13 for a 427.8 intensity of 1663 R. Since zero volts is an output of 63 and 5 volts is zero, this yields the following calibration (at 427.8; G = 25 Linear).

1 volt = 4,300 R

5 volts = 21,500 R

Standardizing to a gain of 63 db yields, for F1, (427.8; G = 63, linear)

1 volt = 54.1 R

5 volts = 270 R

3.2. Calibration of F2

A number or coordinated satellite and aircraft observations were made during the course of the program. For purposes of F2 calibration, the coordinated event of 27 September, 1979 is used. During this series of coordinated aircraft flights, the AFGL/OP NKC-135 (SN 53120)

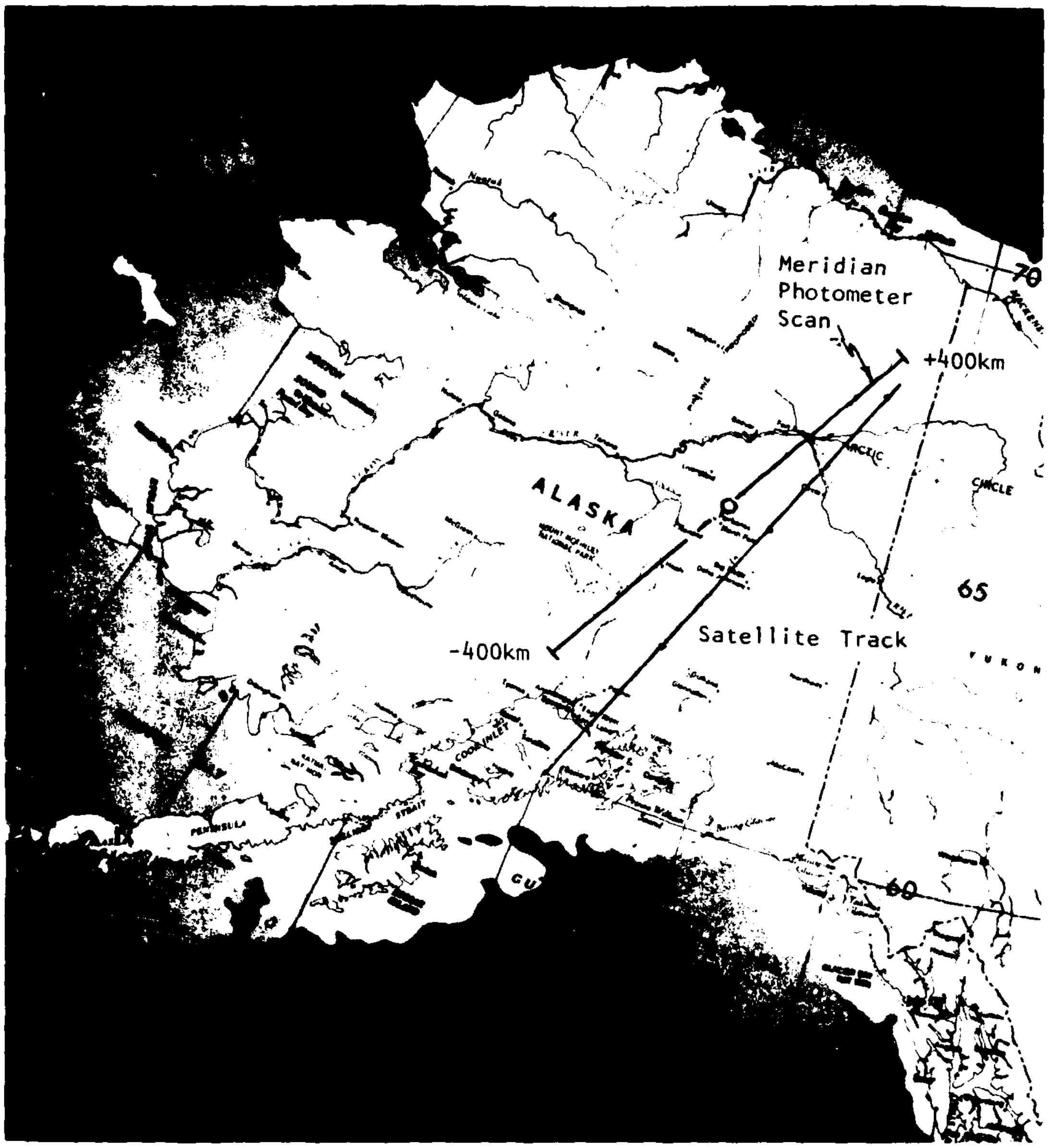

Figure 3-3. Satellite and Ground Station Tracks for F1 (5 February 1979).

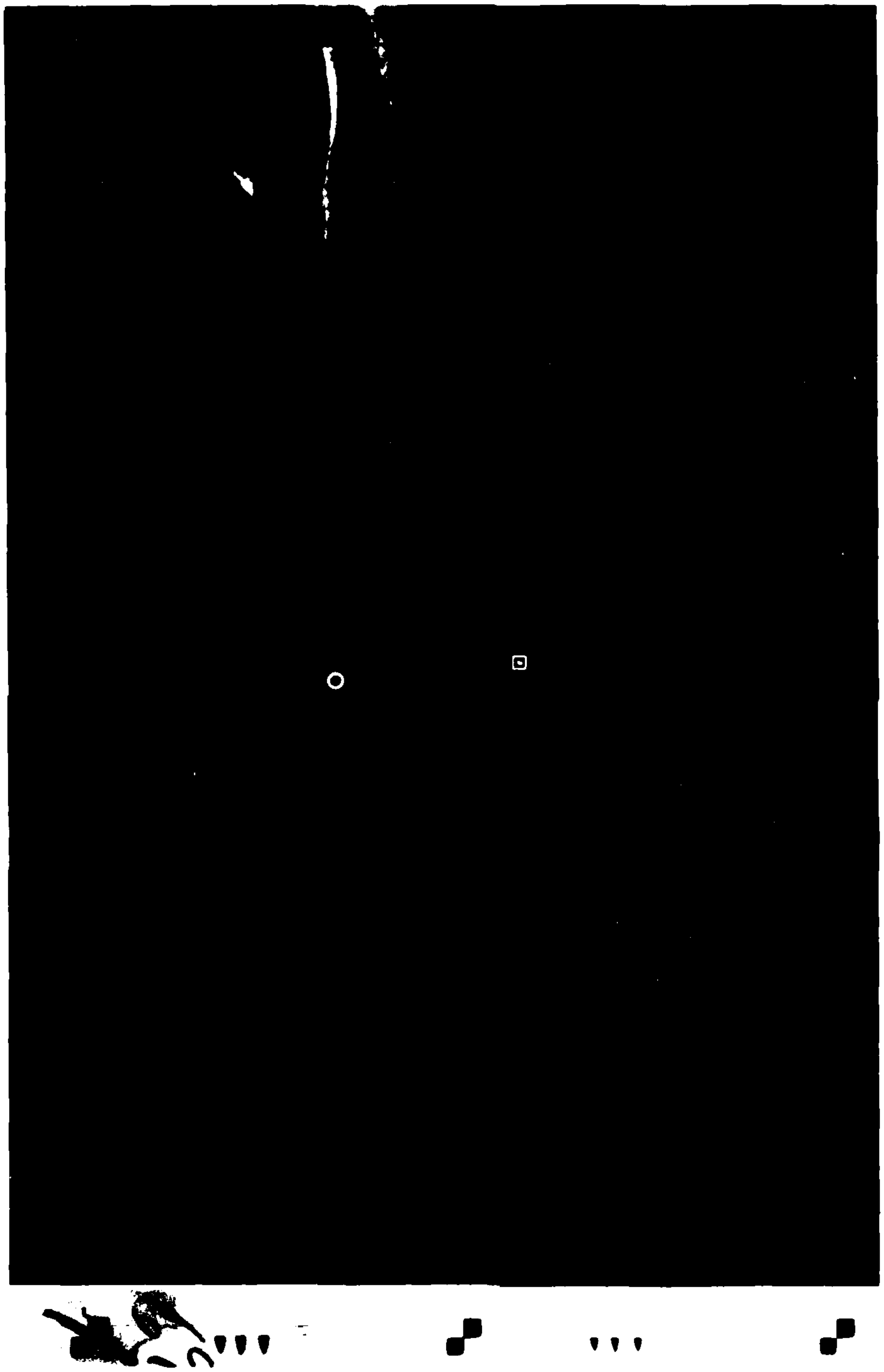

Figure 3-4. DMSP Photo Over Alaska (F1, 5 February 1979).

Table 3-2. GROUND SITE/DMSP F1 COINCIDENCE

(5 February 1979)

Distance South (km)	Photometer Time (U.T.	F1 Time (U.T.)	F1 Output (63 to 0 = 0 to 5 volts)	Ground Site I (4278) (R)
48	10:15:03	10:14:53	59.4	1115
58.2	10:15:01	10:14:55	58.9	1376
68.7	10:14:59	10:14:57	58.35	1569
79.8	10:14:57	10:14:59	57.9	1756
93.4	10:14:55	10:15:01	57.8	1937
109	10:14:43	10:15:04	57.6	2064
123	10:14:51	10:15:06	57.5	2417
140	10:14:49	10:15:09	56.8	2554

was operating from Pease AFB, New Hampshire, flying over Newfoundland and Quebec and returning to Pease. Two revolutions of F2 (Rev 11960 and Rev 11961) scanned regions of aurora which were viewed simultaneously by the AFGL twelve channel visible photometer (System E5 operated by PhotoMetrics). This photometer was near zenith (15° forward) pointing. Table 3-3 shows the aircraft coordinates (from the flight log) and the subsatellite location near the time of coincidence (1:56 U.T.). Fig 3-5 shows the approximate aircraft position on the Rev 11960 pictorial data.

Figure 3-6 shows the pixel values given from the computer reduction of the F2 Rev 11960 output supplied by AFGWC for the scan which included the photometer field-of-view (2° full angle). Averaging the six pixel values closest to the photometer field yields a pixel value of 26 (where zero to 63 is 5 volts to zero volts). During this portion of the orbit, F2 was operated at gain = 57 in Log mode.

The photometer output at the time of coincidence (1:55:17) yielded a value of 350 R at 427.8 nm.

The calculation of the F2 calibration is as follows. F2 during this time was in its logarithmic mode. The voltage telemetered is still 0 - 5 volts, yielding levels of 0 - 63 for pixel values. The equivalent linear voltage into the log amplifier is given by

$$V_{in} = 0.05 \log^{-1} \left[\frac{5(1 - V_{pix})}{2.5} \right]$$

For our case, $V_{pix} = 26$, yielding

$$V_{in} = 0.05 \log^{-1} 1.75 = 0.747 \text{ volts}$$

0.75 volts in = 350 R (427.8)
1 volt in = 467 R

5 volts in = 2,333R (G = 57)

For G = 63 we have:

Using $\text{dB} = 20 \log \frac{V_2}{V_1}$

1 volt = 234 R (427.8) 5 volts = 1170 R (427.8).

Table 3-3. AIRCRAFT DMSP F2 COINCIDENCE
(27 September 1979)

Time (U.T.)	A/C Lat	A/C Long	A/C Hdng	Comment	F2 Lat	F2 Long	Rev
01:52	51°56'	66°01'	000	Left turn			
01:54	52°06'	66°06'	325	End turn	56°04'	57°18'	11960
01:56	52°	66°19'	325°		49°18'	60°51'	11960
02:03	53°03'	67°02'	327°				

Figure 3-5. DMSP Photograph (F2, 27 September 1979).

DMSPF2 AURORAL STRUCTURE REV 11960 SEP 27, 1979

SCAN	TIME	LAT	LONG	ALT	OMGT	AZ	GAIN
602	1155117./19	51.69	59.70	867.9	100.0	165.93	00000000711700264066

MINMAX 7 48 0'S 681-157

#	V	LAT	LONG	AZT	DST	#	V	LAT	LONG	AZT	DST	#	V	LAT	LONG	AZT	DST
169	24	52.17	63.13	281.37	240.4	219	31	52.30	64.22	280.51	316.3	269	25	52.42	65.38	279.59	395.8
170	21	52.17	63.15	281.36	241.9	220	28	52.30	64.25	280.49	317.8	270	27	52.42	65.40	279.58	397.5
171	32	52.17	63.17	281.34	243.4	221	28	52.30	64.27	280.47	319.4	271	31	52.43	65.42	279.56	399.1
172	33	52.17	63.19	281.32	244.9	222	27	52.30	64.29	280.45	320.9	272	28	52.43	65.45	279.54	400.7
173	32	52.18	63.21	281.31	246.4	223	30	52.31	64.31	280.44	322.5	273	28	52.43	65.47	279.52	402.4
174	22	52.18	63.24	281.29	247.9	224	27	52.31	64.34	280.42	324.1	274	34	52.43	65.50	279.50	404.0
175	26	52.18	63.26	281.27	249.4	225	30	52.31	64.36	280.40	325.6	275	31	52.44	65.52	279.48	405.7
176	30	52.18	63.28	281.25	250.9	226	29	52.31	64.38	280.38	327.2	276	25	52.44	65.54	279.46	407.3
177	23	52.19	63.30	281.24	252.4	227	26	52.32	64.40	280.37	328.7	277	27	52.44	65.57	279.44	409.0
178	33	52.19	63.32	281.22	253.9	228	27	52.32	64.43	280.35	330.3	278	23	52.44	65.59	279.42	410.6
179	36	52.19	63.34	281.20	255.4	229	25	52.32	64.45	280.33	331.9	279	32	52.45	65.62	279.40	412.3
180	30	52.20	63.36	281.19	256.9	230	30	52.32	64.47	280.31	333.4	280	31	52.45	65.64	279.39	413.9
181	29	52.20	63.39	281.17	258.4	231	24	52.33	64.49	280.29	335.0	281	16	52.45	65.66	279.37	415.6
182	29	52.20	63.41	281.15	259.9	232	20	52.33	64.52	280.28	336.6	282	28	52.45	65.69	279.35	417.2
183	31	52.20	63.43	281.14	261.4	233	23	52.33	64.54	280.26	338.1	283	36	52.45	65.71	279.33	418.9
184	26	52.21	63.45	281.12	262.9	234	31	52.33	64.56	280.24	339.7	284	33	52.46	65.74	279.31	420.5
185	31	52.21	63.47	281.10	264.4	235	24	52.34	64.58	280.22	341.3	285	39	52.46	65.76	279.29	422.2
186	34	52.21	63.49	281.08	265.9	236	21	52.34	64.61	280.20	342.9	286	37	52.46	65.79	279.27	423.9
187	32	52.21	63.52	281.07	267.4	237	26	52.34	64.63	280.19	344.4	287	29	52.46	65.81	279.25	425.5
188	40	52.22	63.54	281.05	268.9	238	27	52.34	64.65	280.17	346.0	288	19	52.47	65.83	279.23	427.2
189	34	52.22	63.56	281.03	270.4	239	29	52.35	64.68	280.15	347.6	289	25	52.47	65.86	279.21	428.9
190	27	52.22	63.58	281.02	271.9	240	27	52.35	64.70	280.13	349.2	290	31	52.47	65.88	279.19	430.5
191	38	52.22	63.60	281.00	273.4	241	26	52.35	64.72	280.11	350.8	291	30	52.47	65.91	279.17	432.2
192	31	52.23	63.62	280.98	274.9	242	25	52.35	64.75	280.09	352.4	292	25	52.48	65.93	279.15	433.9
193	26	52.23	63.65	280.96	276.4	243	23	52.36	64.77	280.08	354.0	293	23	52.48	65.96	279.13	435.6
194	39	52.23	63.67	280.95	278.0	244	20	52.36	64.79	280.06	355.5	294	22	52.48	65.98	279.12	437.2
195	30	52.23	63.69	280.93	279.5	245	27	52.36	64.81	280.04	357.1	295	18	52.48	66.01	279.10	438.9
196	31	52.24	63.71	280.91	281.0	246	23	52.36	64.84	280.02	358.7	296	25	52.49	66.03	279.08	440.6
197	30	52.24	63.73	280.89	282.5	247	26	52.37	64.86	280.00	360.3	297	33	52.49	66.05	279.06	442.3
198	31	52.24	63.76	280.88	284.0	248	27	52.37	64.88	279.98	361.9	298	28	52.49	66.08	279.04	444.0
199	31	52.24	63.78	280.86	285.6	249	22	52.37	64.91	279.97	363.5	299	26	52.49	66.10	279.02	445.7
200	30	52.25	63.80	280.84	287.1	250	24	52.37	64.93	279.95	365.1	300	29	52.50	66.13	279.00	447.4
201	31	52.25	63.82	280.82	288.6	251	25	52.38	64.95	279.93	366.7	301	26	52.50	66.15	278.98	449.1
202	32	52.25	63.84	280.81	290.1	252	23	52.38	64.98	279.91	368.3	302	27	52.50	66.18	278.96	450.8
203	36	52.25	63.87	280.79	291.7	253	19	52.38	65.00	279.89	369.9	303	27	52.50	66.20	278.94	452.5
204	35	52.26	63.89	280.77	293.2	254	19	52.38	65.02	279.87	371.5	304	19	52.51	66.23	278.92	454.2
205	35	52.26	63.91	280.75	294.7	255	19	52.39	65.05	279.86	373.1	305	20	52.51	66.25	278.90	455.9
206	32	52.26	63.93	280.74	296.2	256	18	52.39	65.07	279.84	374.7	306	22	52.51	66.28	278.88	457.6
207	25	52.27	63.95	280.72	297.8	257	19	52.39	65.09	279.82	376.4	307	18	52.51	66.30	278.86	459.3
208	33	52.27	63.98	280.70	299.3	258	25	52.39	65.12	279.80	378.0	308	20	52.51	66.33	278.84	461.0
209	36	52.27	64.00	280.68	300.8	259	24	52.40	65.14	279.78	379.6	309	33	52.52	66.35	278.82	462.7
210	26	52.27	64.02	280.67	302.4	260	26	52.40	65.16	279.76	381.2	310	26	52.52	66.38	278.80	464.4
211	26	52.28	64.04	280.65	303.9	261	29	52.40	65.19	279.74	382.8	311	22	52.52	66.40	278.78	466.1
212	32	52.28	64.07	280.63	305.5	262	32	52.40	65.21	279.73	384.4	312	20	52.52	66.43	278.76	467.8
213	34	52.28	64.09	280.61	307.0	263	33	52.41	65.23	279.71	386.1	313	24	52.53	66.45	278.74	469.6
214	30	52.28	64.11	280.60	308.5	264	25	52.41	65.26	279.69	387.7	314	25	52.53	66.48	278.72	471.3
215	28	52.29	64.13	280.58	310.1	265	23	52.41	65.28	279.67	389.3	315	21	52.53	66.50	278.70	473.0
216	27	52.29	64.16	280.56	311.6	266	27	52.41	65.31	279.65	390.9	316	25	52.53	66.53	278.68	474.7
217	27	52.29	64.18	280.54	313.2	267	16	52.42	65.33	279.63	392.6	317	25	52.54	66.55	278.66	476.5
218	30	52.29	64.20	280.53	314.7	268	21	52.42	65.35	279.61	394.2	318	18	52.54	66.58	278.64	478.2

Figure 3-6. Pixel Values for F-2/Aircraft Coincidence.

3.3 Calibration Summary

As shown in Section 3.1 and 3.2, the calibration of F1, from a coincident measurement with the Chatanika Meridian Scanning Photometer and the calibration of F2 from a coincident measurement with the AFGL/OP NKC-135 are:

F1 (Linear Mode)

$$1 \text{ volt} = 54.1 \times \log^{-1} \left(\frac{63-G}{20}\right) R\ (427.8)$$

where

$$G = \text{gain}$$

$$\text{volts} = 5\left(1 - \frac{V_{pix}}{63}\right)$$

$$V_{pix} = \text{telemetered pixel value (0 to 63)}$$

$$I\ (427.8) = 270 \left(1 - \frac{V_{pix}}{63}\right) \log^{-1} \left(\frac{63 - G}{20}\right) R$$

F2 (Linear Mode)

$$I\ (427.8) = 1{,}170 \left(1 - \frac{V_{pix}}{63}\right) \log^{-1} \left(\frac{63 - G}{20}\right) R$$

For the log mode we have

F1 (log)

$$I\ (427.8) = 2.7 \log^{-1} \left[2 \left(1 - \frac{V_{pix}}{63}\right)\right] \log^{-1} \left[\frac{63 - G}{20}\right] R$$

F2 (log)

$$I\ (427.8) = 11.7 \log^{-1} \left[2 \left(1 - \frac{V_{pix}}{63}\right)\right] \log^{-1} \left[\frac{63 - G}{20}\right] R$$

4. TREATMENT OF DATA

As mentioned earlier, the DMSP data of interest has been most recently supplied on magnetic tape by AFGWC. Figure 3-2 showed a dump of the tape data. Figure 4-1 gives the format of the data as supplied. The data for each scan line is composed of 250 36 bit words. Each 36 bit word, as seen in Figure 3-2, is composed of 12 octal digits (0 - 7). From the format of Fig 4-1, it can be seen that the first two words contain Line Count and Sync information. The pixel data is contained in the following 244 words as pairs of octal digits yielding levels of 0 - 63 for each pixel. Word 247 contains the time code as a 27 bit (9 octal digits) number representing U.T. in seconds times 1024. Word 248 contains a 9 bit (3 octal) number for the gain setting, with G1= MSB and G9 = LSB. G1 - G6 represent the whole number G = zero to G = 63 values. Word 248 also contains a 4 bit number (M1 - M4). M1 gives information as to whether the amplifier is operating in linear or log mode. A zero in this position is used for linear and a 1 for log. M2 - M4, if all 1's, tell us that the amplifier was in preset gain mode. Other options are various AGC modes. The remaining bits in words 248 - 250 give calibration information for the various detectors and also vehicle identification.

Figure 4-2 illustrates the operations which are performed on the data. The digital data, as received from AFGWC on magnetic tape, is operated on by program PIXEL. This program unpacks data from the time interval of interest and merges this data with satellite ephemeris data for the time of interest for the particular satellite. This merged data, which now contains coordinate and time information for every pixel, is reformatted and output is made to permanent file for later use. PIXEL 2 is used only to provide a viewable output of this merged, reformatted data.

ARCLDB is a program used to produce a data base along an arc at an arbitrary angle to the satellite trajectory. This is necessary in order to compare the DMSP measurement with those of another instrument on the ground, on an aircraft, or on another satellite viewing a region

Word #1 — Frame/Line Count

35	34		0
	Frame Count	Line Count	

1 = L
0 = T

Word #2 — Computer Line Sync

35	34					0
	00000	000000	111111	011111	000001	Q1-4 00

1 = L
0 = T

Words #3 Thru #246 (#3 Thru #124 For Sample ÷ 2 Or Avg 2 x 2)
(#3 Thru # 63 For Sample ÷ 4 Or Avg 4 x 4)

35						0
6 Bit Data	6 Bit Data	6 Bit Data	6 Bit Data	6 Bit Data	6 Bit Data	

Word #247
(#125 For Sample ÷ 2 Or #125 For Avg 2 x 2, Line 2)
#129 For Avg 2 x 2, Line 1
(# 64 For Sample ÷ 4 Or # 64 For Avg 4 x 4, Line 4)
68 For Avg 4 x 4, Line 3
72 For Avg 4 x 4, Line 2
76 For Avg 4 x 4, Line 1

35					0
000000	000 E1-3	E4-9	E10-15	E16-21	E22-27

Word #248
(#126 For Sample ÷ 2 Or #126 For Avg 2 x 2, Line 2)
#130 For Avg 2 x 2, Line 1
(# 65 For Sample ÷ 4 Or # 65 For Avg 4 x 4, Line 4)
69 For Avg 4 x 4, Line 3
73 For Avg 4 x 4, Line 2
77 For Avg 4 x 4, Line 1

35						0
G1-6	G7-9 M1-3	M4 S P1-4	P5-8 I1-2	I3-4 S H0-2	H3-8	

Word #249
(#127 For Sample ÷ 2 Or #127 For Avg 2 x 2, Line 2)
#131 For Avg 2 x 2, Line 1
(# 66 For Sample ÷ 4 Or # 66 For Avg 4 x 4, Line 4)
70 For Avg 4 x 4, Line 3
74 For Avg 4 x 4, Line 2
78 For Avg 4 x 4, Line 1

35						0
Y1-4 S C0	C1-6	C7-8 Z1-4	Z5-10	Z11-16	Z17-22	

Word #250
(#128 For Sample ÷ 2 Or #128 For Avg 2 x 2, Line 2)
#132 For Avg 2 x 2, Line 1
(# 67 For Sample ÷ 4 Or # 67 For Avg 4 x 4, Line 4)
71 For Avg 4 x 4, Line 3
75 For Avg 4 x 4, Line 2
79 For Avg 4 x 4, Line 1

35						0
Z23-28	Z29-32 XX	000000	000000	000000	000000	

X May Be Either 1 Or 0

FORMATTED 6-BIT SMOOTH DATA OUTPUT

Figure 4-1. Format of Block 5D Tape Data.

DATA FLOW BLOCK DIAGRAM

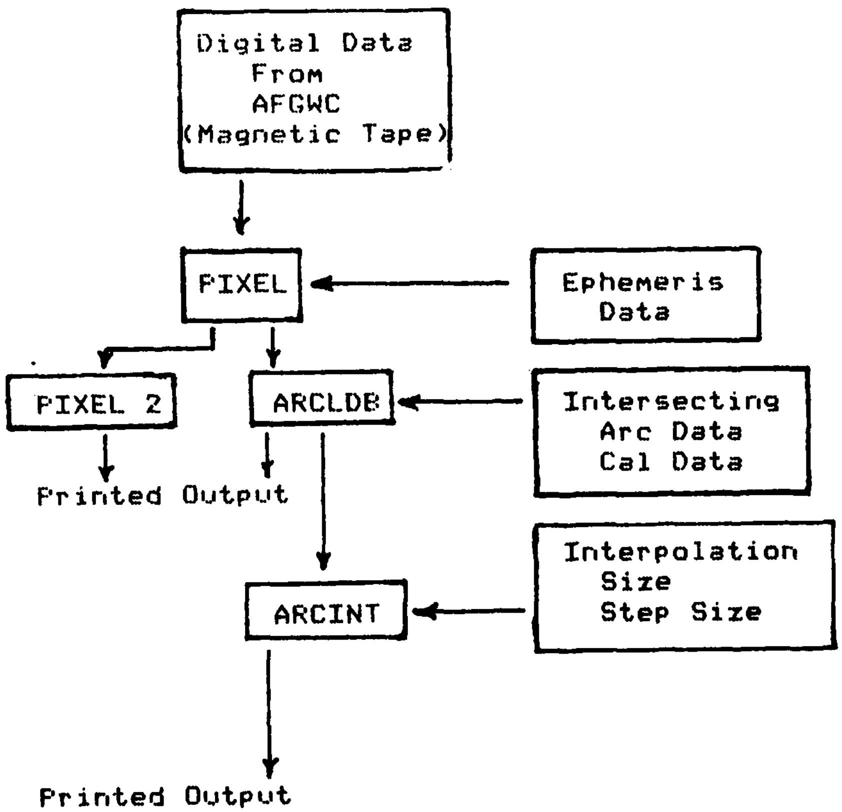

Figure 4-2.

viewed by DMSP. The absolute calibration of the sensor is inserted in ARCLDB so that results are in kR.

The program ARCINT uses the data base produced by ARCLDB to compute, by interpolation, the intensity as measured by DMSP along an arc centered at an arbitrary point and at an arbitrary angle.

4.1 Event of 11 January, 1980

As an example of the output of the various data processing programs we use data taken by satellite F2 on 11 January, 1980. Fig 4-3 is a reproduction of the transparency as supplied by AFGWC for the time period near 20 hrs 27 min UT. The satellite was moving downward during this period. The pairs of squares in the left margin occur every 120 seconds. The upper pair are at a time of 20:25.7 UT. The large city in the lower right corner is Moscow, with Leningrad visible as the next largest city to the northwest.

Fig. 4-4 shows the output of program PIXEL 2 for a 10 second time portion roughly midway between the upper two pairs of time squares. This is an example of short-form printout for the merged pixel-geographic information. A minimal amount of data is shown for each scan line. This includes the time of the scan, subsatellite coordinates, altitude of the satellite, the altitude assumed for the aurora (100 km), the octal digits which give the gain (in this case 310 octal or 011001000 binary, yielding G = 25) and state of the amplifier (74 octal or 111100 binary, yielding log preset gain). The final set of columns give the minimum and maximum decimal values for pixels on that scan line and the location pixel number of these values. Pixel number runs from -732 to 732. It should be remembered that minimum decimal value represents maximum signal. Negative pixel location numbers are on the right half of the picture. Figure 4-5 is the long-form output of PIXEL 2, showing coordinates and values for every pixel in a particular scan.

Figure 4-6 shows the output of program ARCLDB for points near a portion of the line drawn on the photo in Figure 4-3 representing the intersection of an arbitrary scan by another instrument with the

Figure [illegible] Photograph #2, 11 June [illegible]

```
================================ 03/20/81 ================================

INITIATOR       : G. DAVIDSON
PROBLEM NO.     : 1786
MONITOR         : R. NADILE
PROGRAMMER      : H FIDH, ROP          RUN BY    : G. DAVIDSON

EXPERIMENT      : DMSP AURORAL SPATIAL STRUCTURE
DATA            : TAPE D13474 DMSPF2 PASS 13474   JAN 11, 1980
TEST CASE FOR ARC DATA BASE PROGRAM

=========================================================================
```

1DMSPF2 AURORAL STRUCTURE REV 13474 JAN 11,1980

SCAN	TIME	LAT	LONG	ALT	DHGT	AZ	GAIN	
1228	20:26:49.591	69.72	319.41	829.1	100.0	154.23	00000000310740264067	MIDMAX 34 62 0'S -16 425
1229	20:26:49.170	69.74	319.37	829.1	100.0	154.20	00000000310740264067	MIDMAX 32 62 0'S -20 702
1230	20:26:48.750	69.76	319.34	829.1	100.0	154.17	00000000310740270067	MIDMAX 35 62 0'S -18 731
1231	20:26:48.329	69.78	319.31	829.1	100.0	154.14	00000000310740270067	MIDMAX 34 62 0'S -22 405
1232	20:26:47.908	69.81	319.27	829.1	100.0	154.12	00000000310740265067	MIDMAX 36 62 0'S -31 393
1233	20:26:47.487	69.83	319.24	829.1	100.0	154.09	00000000310740264067	MIDMAX 36 62 0'S -29 559
1234	20:26:47.067	69.85	319.20	829.0	100.0	154.06	00000000310740270067	MIDMAX 37 62 0'S -30 374
1235	20:26:46.646	69.87	319.17	829.0	100.0	154.03	00000000310740270067	MIDMAX 36 62 0'S -41 387
1236	20:26:46.226	69.89	319.13	829.0	100.0	154.00	00000000310740265067	MIDMAX 34 62 0'S -40 633
1237	20:26:45.805	69.92	319.10	829.0	100.0	153.97	00000000310740264067	MIDMAX 35 62 0'S -46 365
1238	20:26:45.384	69.94	319.06	829.0	100.0	153.94	00000000310740265467	MIDMAX 34 62 0'S -66 363
1239	20:26:44.964	69.96	319.03	829.0	100.0	153.91	00000000310740265467	MIDMAX 34 62 0'S -70 545
1240	20:26:44.543	69.98	318.99	829.0	100.0	153.88	00000000310740264067	MIDMAX 32 62 0'S -90 405
1241	20:26:44.122	70.01	318.96	829.0	100.0	153.85	00000000310740265067	MIDMAX 31 62 0'S -85 521
1242	20:26:43.701	70.03	318.92	829.0	100.0	153.82	00000000310740270067	MIDMAX 30 62 0'S -92 732
1243	20:26:43.280	70.05	318.89	828.9	100.0	153.79	00000000310740270067	MIDMAX 30 62 0'S -93 582
1244	20:26:42.860	70.07	318.85	828.9	100.0	153.76	00000000310740264067	MIDMAX 28 62 0'S-102 406
1245	20:26:42.439	70.09	318.82	828.9	100.0	153.73	00000000310740264067	MIDMAX 25 62 0'S-126 408
1246	20:26:42.019	70.12	318.78	828.9	100.0	153.70	00000000310740270067	MIDMAX 25 62 0'S-130 427
1247	20:26:41.598	70.14	318.74	828.9	100.0	153.67	00000000310740270067	MIDMAX 24 62 0'S-135 421
1248	20:26:41.178	70.16	318.71	828.9	100.0	153.64	00000000310740264067	MIDMAX 22 62 0'S-138 690
1249	20:26:40.757	70.18	318.67	828.9	100.0	153.61	00000000310740264067	MIDMAX 22 62 0'S-142 420
1250	20:26:40.336	70.20	318.64	828.9	100.0	153.58	00000000310740270067	MIDMAX 23 62 0'S-144 732

Figure 4-4. Short-Form Output of Program PIXEL 2.

02/24/81

INITIATOR : C. DAVIDSON
PROBLEM NO. : 1706
MONITOR : R. NADILE
PROGRAMMER : M FISH, RDP RUN BY : C. DAVIDSON

EXPERIMENT : DMSP AURORAL SPATIAL STRUCTURE
DATA : TAPE D13474 DMSPF2 PASS 13474 JAN 11, 1980
TEST CASE FOR ARC DATA BASE PROGRAM

10MSPF2 AURORAL STRUCTURE REV 13474 JAN 11,1980

SCAN TIME LAT LONG ALT ONGT AZ ZADN

1097 20127199.702 66.77 323.39 830.6 100.0 157.54 000000003107902606?? KIDNAK 22 62 0'S 430 -19

#	V	LAT	LONG	AZT	DST	#	V	LAT	LONG	AZT	DST	#	V	LAT	LONG	AZT	DST
-732	56	60.52	301.43	132.21	-1275.1	-682	58	61.09	302.75	131.06	-1179.0	-632	57	61.71	304.27	129.73	-1073.8
-731	56	60.53	301.45	132.19	-1273.4	-681	58	61.10	302.77	131.04	-1177.0	-631	58	61.72	304.30	129.70	-1071.6
-730	59	60.54	301.48	132.17	-1271.6	-680	56	61.11	302.80	131.01	-1175.0	-630	58	61.73	304.33	129.67	-1069.4
-729	58	60.55	301.50	132.15	-1269.9	-679	58	61.12	302.83	130.99	-1173.7	-629	58	61.74	304.36	129.64	-1067.2
-728	57	60.56	301.53	132.13	-1268.1	-678	58	61.13	302.86	130.96	-1171.6	-628	59	61.76	304.39	129.62	-1065.1
-727	58	60.57	301.55	132.11	-1266.3	-677	57	61.15	302.89	130.94	-1169.6	-627	60	61.77	304.42	129.59	-1062.9
-726	59	60.58	301.57	132.09	-1264.6	-676	57	61.16	302.92	130.91	-1167.5	-626	56	61.78	304.46	129.56	-1060.7
-725	59	60.59	301.60	132.06	-1262.8	-675	59	61.17	302.95	130.89	-1165.4	-625	59	61.79	304.49	129.53	-1058.5
-724	58	60.60	301.62	132.04	-1261.0	-674	59	61.18	302.98	130.86	-1163.4	-624	61	61.81	304.52	129.50	-1056.3
-723	58	60.61	301.65	132.02	-1259.2	-673	60	61.20	303.01	130.83	-1161.3	-623	61	61.82	304.55	129.47	-1054.1
-722	58	60.62	301.67	132.00	-1257.4	-672	61	61.21	303.04	130.81	-1159.2	-622	60	61.83	304.59	129.45	-1052.0
-721	58	60.63	301.70	131.98	-1255.6	-671	60	61.22	303.07	130.78	-1157.1	-621	59	61.84	304.62	129.42	-1049.8
-720	60	60.65	301.72	131.96	-1253.7	-670	59	61.23	303.10	130.76	-1155.0	-620	57	61.86	304.65	129.39	-1047.6
-719	60	60.66	301.75	131.94	-1251.9	-669	59	61.25	303.12	130.73	-1153.0	-619	57	61.87	304.68	129.36	-1045.4
-718	59	60.67	301.77	131.91	-1250.1	-668	56	61.26	303.15	130.70	-1150.9	-618	58	61.88	304.71	129.33	-1043.2
-717	57	60.68	301.80	131.89	-1248.2	-667	59	61.27	303.18	130.68	-1148.8	-617	58	61.89	304.75	129.30	-1041.0
-716	61	60.69	301.82	131.87	-1246.4	-666	58	61.28	303.21	130.65	-1146.7	-616	58	61.91	304.78	129.28	-1038.8
-715	59	60.70	301.85	131.85	-1244.5	-665	57	61.29	303.24	130.63	-1144.6	-615	59	61.92	304.81	129.25	-1036.7
-714	59	60.71	301.87	131.82	-1242.7	-664	56	61.31	303.27	130.60	-1142.5	-614	59	61.93	304.84	129.22	-1034.5
-713	61	60.72	301.90	131.80	-1240.8	-663	59	61.32	303.30	130.57	-1140.3	-613	59	61.94	304.88	129.19	-1032.3
-712	60	60.73	301.92	131.78	-1238.9	-662	60	61.33	303.33	130.55	-1138.2	-612	59	61.96	304.91	129.16	-1030.1
-711	59	60.75	301.95	131.76	-1237.0	-661	58	61.34	303.36	130.52	-1136.1	-611	58	61.97	304.94	129.13	-1027.9
-710	57	60.76	301.98	131.73	-1235.1	-660	57	61.36	303.39	130.49	-1134.0	-610	56	61.98	304.97	129.10	-1025.7
-709	57	60.77	302.00	131.71	-1233.2	-659	61	61.37	303.43	130.47	-1131.9	-609	61	61.99	305.01	129.07	-1023.5
-708	57	60.78	302.03	131.69	-1231.3	-658	60	61.38	303.46	130.44	-1129.7	-608	61	62.01	305.04	129.05	-1021.3
-707	58	60.79	302.06	131.67	-1229.4	-657	59	61.39	303.49	130.41	-1127.6	-607	57	62.02	305.07	129.02	-1019.1
-706	60	60.80	302.08	131.64	-1227.5	-656	59	61.41	303.52	130.39	-1125.5	-606	58	62.03	305.10	128.99	-1016.9
-705	58	60.81	302.11	131.62	-1225.6	-655	58	61.42	303.55	130.36	-1123.4	-605	58	62.04	305.14	128.96	-1014.8
-704	59	60.83	302.13	131.60	-1223.6	-654	60	61.43	303.58	130.33	-1121.2	-604	58	62.06	305.17	128.93	-1012.6
-703	59	60.84	302.16	131.57	-1221.7	-653	56	61.44	303.61	130.31	-1119.1	-603	60	62.07	305.20	128.90	-1010.4
-702	57	60.85	302.19	131.55	-1219.8	-652	58	61.46	303.64	130.28	-1117.0	-602	59	62.08	305.24	128.87	-1008.2
-701	59	60.86	302.22	131.53	-1217.8	-651	56	61.47	303.67	130.25	-1114.8	-601	58	62.09	305.27	128.84	-1006.0
-700	59	60.87	302.24	131.50	-1215.9	-650	55	61.48	303.70	130.22	-1112.7	-600	59	62.10	305.30	128.81	-1003.8
-699	58	60.88	302.27	131.48	-1213.9	-649	60	61.49	303.73	130.20	-1110.5	-599	59	62.12	305.33	128.78	-1001.6
-698	59	60.90	302.30	131.45	-1211.9	-648	58	61.51	303.76	130.17	-1108.4	-598	58	62.13	305.37	128.76	-999.4
-697	57	60.91	302.32	131.43	-1210.0	-647	57	61.52	303.79	130.14	-1106.2	-597	60	62.14	305.40	128.73	-997.2
-696	58	60.92	302.35	131.41	-1208.0	-646	58	61.53	303.82	130.12	-1104.1	-596	61	62.15	305.43	128.70	-995.0
-695	58	60.93	302.38	131.38	-1206.0	-645	58	61.54	303.86	130.09	-1101.9	-595	60	62.17	305.47	128.67	-992.8
-694	58	60.94	302.41	131.36	-1204.0	-644	57	61.56	303.89	130.06	-1099.8	-594	59	62.18	305.50	128.64	-990.7
-693	59	60.95	302.43	131.33	-1202.1	-643	58	61.57	303.92	130.03	-1097.6	-593	59	62.19	305.53	128.61	-988.5
-692	60	60.97	302.46	131.31	-1200.1	-642	58	61.58	303.95	130.01	-1095.4	-592	59	62.20	305.57	128.58	-986.3
-691	56	60.98	302.49	131.29	-1198.1	-641	57	61.59	303.98	129.98	-1093.3	-591	57	62.22	305.60	128.55	-984.1
-690	57	60.99	302.52	131.26	-1196.1	-640	61	61.61	304.01	129.95	-1091.1	-590	60	62.23	305.63	128.52	-981.9
-689	57	61.00	302.55	131.24	-1194.0	-639	60	61.62	304.04	129.92	-1089.0	-589	58	62.24	305.66	128.49	-979.7
-688	59	61.01	302.57	131.21	-1192.0	-638	58	61.63	304.08	129.90	-1086.8	-588	56	62.25	305.70	128.46	-977.5
-687	59	61.03	302.60	131.19	-1190.0	-637	58	61.44	304.11	129.87	-1084.6	-587	59	62.26	305.73	128.43	-975.3

Figure 4-5. Long-Form Output of PIXEL 2.

```
DMSP AURORAL STRUCTURE STUDIES - ARC CALIBRATION DATA BASE

SATELLITE DMSPF2    PASS 13074  01/11/80

ARC PARAMETERS
        LATITUDE      70.000 DEG N   LONGITUDE     320.500 DEG W;  AZIMUTH    325.000 DEG E FROM N
        HALF-LENGTH   400.000 KM;  HALF-WIDTH      9.000 KM;  DELS      2.000 KM
        HEIGHT    100.000 KM

GAIN =     10.600

EQUATOR TO ARC TRANSFORMATION MATRIX
        .26391    .22912   -.93694
        .21755    .93221    .28924
        .93969   -.28017    .19617

FOLLOWING DATA PRINTOUT PER INTERSECTING SCAN:
     SCAN  (SCAN NUMBER)
     TIME  (UT,SEC)
     SLAT  (GEOGRAPHIC SATELLITE LATITUDE,DEG)
     SLON  (GEOGRAPHIC SATELLITE LONGITUDE,DEG W)
     SLATA (SATELLITE LATITUDE IN ARC COORDINATE SYSTEM,DEG)
     SLONA (SATELLITE LONGITUDE IN ARC COORDINATE SYSTEM,DG W)
     SALT  (SATELLITE ALTITUDE,KM)
     SAZA  (SATELLITE TRACK AZIMUTH IN ARC SYSTEM,DEG E OF N)
     SARC  (DISTANCE ALONG ARC TO INTERSECTION IN UNITS OF DELS)
     SPIX  (FRACTIONAL PIXEL NUMBER AT INTERSECTION)
     NPIX  (NUMBER OF PIXELS SELECTED FOR DATA BASE)
     KPIX  (LOWEST ALGEBRAIC PIXEL NUMBER OF GROUP SELECTED)
   FOLLOWED BY INTENSITIES IN KILORAYLEIGHS FOR THESE PIXELS
```

Figure 4-6. Output of Program ARCLDB

```
          DMSP AURORAL STRUCTURE - ARC DATA BASE
    SCAN INFO FOLLOWED BY PIXEL INTENSITIES IN INCREASING ORDER OF PIXEL NUMBER

SCAN    TIME     SLAT    SLON    SLATA   SLONA   SALT     SAZA     SARC     SPIX   NPIX KPIX

1229 73609.170  69.740 319.375    .172   -.434 829.104  149.741   -5.594   28.650   26   16
           .12885E+01  .12885E+01  .11132E+01  .89403E+00  .89403E+00  .11132E+01
           .10340E+01  .11132E+01  .89403E+00  .10340E+01  .89403E+00  .89403E+00
           .83101E+00  .83101E+00  .89403E+00  .89403E+00  .96183E+00  .89403E+00
           .71790E+00  .83101E+00  .89403E+00  .89403E+00  .83101E+00  .77243E+00
           .77243E+00  .10340E+01

1230 73608.750  69.762 319.340    .194   -.422 829.093  149.738   -3.591   32.343   26   20
           .10340E+01  .11132E+01  .10340E+01  .96183E+00  .96183E+00  .89403E+00
           .96183E+00  .11132E+01  .10340E+01  .10340E+01  .10340E+01  .11977E+01
           .89403E+00  .77243E+00  .71790E+00  .83101E+00  .10340E+01  .89403E+00
           .77243E+00  .89403E+00  .11132E+01  .77243E+00  .83101E+00  .89403E+00
           .71790E+00  .66737E+00

1231 73608.329  69.784 319.306    .216   -.410 829.081  149.735   -1.583   36.042   27   23
           .11977E+01  .11977E+01  .11977E+01  .11132E+01  .13862E+01  .11132E+01
           .11977E+01  .11132E+01  .83101E+00  .11132E+01  .10340E+01  .96183E+00
           .83101E+00  .77243E+00  .83101E+00  .83101E+00  .89403E+00  .66737E+00
           .83101E+00  .77243E+00  .83101E+00  .89403E+00  .89403E+00  .77243E+00
           .71790E+00  .89403E+00  .77243E+00

1232 73607.908  69.806 319.271    .239   -.398 829.070  149.732     .424   39.738   26   27
           .11132E+01  .11132E+01  .11132E+01  .11977E+01  .11132E+01  .10340E+01
           .89403E+00  .71790E+00  .62033E+00  .83101E+00  .89403E+00  .83101E+00
           .77243E+00  .83101E+00  .71790E+00  .71790E+00  .89403E+00  .89403E+00
           .83101E+00  .89403E+00  .83101E+00  .10340E+01  .89403E+00  .89403E+00
           .71790E+00  .96183E+00

1233 73607.487  69.828 319.237    .261   -.387 829.059  149.728    2.431   43.431   26   31
           .11132E+01  .89403E+00  .96183E+00  .89403E+00  .71790E+00  .83101E+00
           .96183E+00  .77243E+00  .77243E+00  .83101E+00  .89403E+00  .96183E+00
           .83101E+00  .71790E+00  .89403E+00  .10340E+01  .83101E+00  .71790E+00
           .83101E+00  .83101E+00  .66737E+00  .71790E+00  .83101E+00  .71790E+00
           .71790E+00  .77243E+00

1234 73607.067  69.851 319.202    .283   -.375 829.048  149.725    4.433   47.112   27   34
           .83101E+00  .83101E+00  .89403E+00  .89403E+00  .77243E+00  .89403E+00
           .83101E+00  .83101E+00  .89403E+00  .77243E+00  .71790E+00  .77243E+00
           .83101E+00  .77243E+00  .83101E+00  .71790E+00  .71790E+00  .89403E+00
           .71790E+00  .66737E+00  .77243E+00  .83101E+00  .77243E+00  .77243E+00
           .77243E+00  .62033E+00  .83101E+00

1235 73606.646  69.873 319.167    .305   -.363 829.037  149.722    6.439   50.797   26   38
           .71790E+00  .89403E+00  .77243E+00  .83101E+00  .83101E+00  .83101E+00
           .77243E+00  .83101E+00  .83101E+00  .83101E+00  .71790E+00  .66737E+00
           .71790E+00  .83101E+00  .77243E+00  .71790E+00  .71790E+00  .71790E+00
           .66737E+00  .66737E+00  .77243E+00  .71790E+00  .83101E+00  .89403E+00
           .71790E+00  .83101E+00
```

spherical shell containing the aurora at 100 km. In the photo (Fig 4-3), the right hand portion has been cropped, so that the center of the DMSP scans (the subsatellite track) is actually moved to the right and very nearly passes through the circle representing the center of the arbitrary scan. The arbitrary scan is centered at a latitude of 70° North and longitude of 320.5° West. It is taken at an azimuth of 325° east of north.

Fig 4-6 displays a small portion of the data base of pixels selected for each scan line near the intersection with the arbitrary scan. The calibration data was included as an input to this program, so that pixel values are given in equivalent kR of 4278 Å intensity.

Fig 4-7 shows the output of program ARCINT for the 800 km arbitrary scan intersection, using the data base created by ARCLDB for interpolation of pixel values near the intersection with each scan line. By comparing Fig 4-7 with the photo in Fig 4-3, one can readily see the intercept with the auroral arc. The intensity maximizes at approximately 6.4 kR at -58.5 km.

DMSP AURORAL STRUCTURE STUDIES ARC CALIBRATION DATA BASE

SATELLITE DMSPF2   PASS 13474 01/11/80

ARC PARAMETERS
LATITUDE   70.000 DEG N; LONGITUDE   320.500 DEG W; AZIMUTH   325.000 DEG E FROM N
HALF-LENGTH   400.000 KM; HALF-WIDTH   9.000 KM; DELS   2.800 KM
HEIGHT   100.000 KM

GAIN =   10.600
ISQUAR =   4 IPLOT = 0 DELINT = 2.800

DMSP AURORAL STRUCTURE

S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)	S(KM)	INT(KR)
-403.20	.70	-263.20	.95	-123.20	1.09	16.80	.71	156.80	.71
-400.40	.67	-260.40	.87	-120.40	1.08	19.60	.81	159.60	.80
-397.60	.78	-257.60	1.06	-117.60	1.11	22.40	.73	162.40	.80
-394.80	.77	-254.80	1.14	-114.80	1.15	25.20	.79	165.20	.69
-392.00	.80	-252.00	.95	-112.00	1.29	28.00	.78	168.00	.76
-389.20	.73	-249.20	.84	-109.20	1.33	30.80	.76	170.80	.73
-386.40	.80	-246.40	1.07	-106.40	1.08	33.60	.69	173.60	.63
-383.60	.64	-243.60	1.06	-103.60	1.19	36.40	.74	176.40	.66
-380.80	.79	-240.80	.96	-100.80	1.49	39.20	.81	179.20	.74
-378.00	.78	-238.00	.82	-98.00	1.59	42.00	.87	182.00	.68
-375.20	.80	-235.20	.79	-95.20	1.62	44.80	.74	184.80	.78
-372.40	.81	-232.40	.85	-92.40	1.81	47.60	.71	187.60	.75
-369.60	.91	-229.60	.78	-89.60	1.93	50.40	.70	190.40	.73
-366.E0	.71	-226.80	.96	-86.80	1.96	53.20	.80	193.20	.70
-364.00	.93	-224.00	1.01	-84.00	1.89	56.00	.72	196.00	.72
-361.20	.86	-221.20	.88	-81.20	2.31	58.80	.77	198.80	.76
-358.40	1.02	-218.40	1.05	-78.40	2.26	61.60	.84	201.60	.71
-355.60	.84	-215.60	1.02	-75.60	2.44	64.40	.76	204.40	.74
-352.80	.83	-212.80	1.01	-72.80	3.45	67.20	.80	207.20	.72
-350.00	.77	-210.00	.93	-70.00	3.91	70.00	.75	210.00	.72
-347.20	1.09	-207.20	.83	-67.20	4.10	72.80	.76	212.80	.76
-344.40	.84	-204.40	.89	-64.40	4.08	75.60	.67	215.60	.75
-341.60	.92	-201.60	1.04	-61.60	4.50	78.40	.83	218.40	.68
-338.80	.84	-198.80	1.05	-58.80	6.44	81.20	.87	221.20	.65
-336.00	.84	-196.00	1.21	-56.00	4.29	84.00	.73	224.00	.62
-333.20	1.04	-193.20	1.02	-53.20	3.84	86.80	.69	226.80	.67
-330.40	.92	-190.40	.96	-50.40	2.74	89.60	.94	229.60	.77
-327.60	.93	-187.60	.79	-47.60	2.64	92.40	.64	232.40	.76
-324.80	.98	-184.80	.87	-44.80	2.32	95.20	.95	235.20	.71
-322.00	.88	-182.00	1.10	-42.00	2.17	98.00	.72	238.00	.68
-319.20	.79	-179.20	.78	-39.20	2.33	100.80	.69	240.80	.64
-316.40	1.04	-176.40	1.06	-36.40	2.66	103.60	.69	243.60	.62
-313.60	.91	-173.60	.86	-33.60	1.36	106.40	.71	246.40	.62
-310.80	1.06	-170.80	.96	-30.80	1.62	109.20	.66	249.20	.71
-308.00	.93	-168.00	.92	-28.00	1.16	112.00	.70	252.00	.73
-305.20	.96	-165.20	1.09	-25.20	1.15	114.80	.65	254.80	.74
-302.40	1.09	-162.40	.98	-22.40	1.09	117.60	.72	257.60	.64
-299.60	1.15	-159.60	.97	-19.60	.94	120.40	.84	260.40	.68
-296.80	.89	-156.80	.91	-16.80	.83	123.20	.70	263.20	.67
-294.00	1.15	-154.00	1.10	-14.00	.93	126.00	.75	266.00	.66
-291.20	1.03	-151.20	1.09	-11.20	1.02	128.80	.75	268.80	.67
-288.40	1.14	-148.40	1.02	-8.40	.82	131.60	.66	271.60	.67
-285.60	.95	-145.60	.80	-5.60	.83	134.40	.76	274.40	.72
-282.80	1.02	-142.80	.88	-2.80	.84	137.20	.69	277.20	.72
-280.00	1.20	-140.00	1.00	0.00	.80	140.00	.61	280.00	.71
-277.20	.94	-137.20	.89	2.80	.78	142.80	.73	282.80	.63
-274.40	.86	-134.40	1.06	5.60	.80	145.60	.64	285.60	.66
-271.60	1.07	-131.60	.85	8.40	.77	148.40	.67	288.40	.67
-268.80	.82	-128.80	1.04	11.20	.85	151.20	.68	291.20	.64
-266.00	.82	-126.00	.92	14.00	.79	154.00	.61	294.00	.68

Figure 4-7. Output of Program ARCINT.

5. CONCLUSIONS

Auroral data taken by night time sensors on DMSP has been used in the past to provide information on structure and global motion. Most of this data was extracted from photographic transparencies which had been synthesized by AFGWC from digital information. In this effort we have developed techniques for using digital data directly, thus maintaining the full system capability of the DMSP. In addition, by correlation with calibrated aircraft and ground photometers, we have calibrated the night time sensors on DMSP F1 and F2. This, then, yields calibrated downward looking auroral and airglow sensors with global coverage.

The computer techniques which have been developed should allow prediction of intensity levels seen by other satellites viewing portions of the regions covered by DMSP. As future DMSP satellites are launched, the technique will allow study of spatial frequencies in aurora and airglow and should add considerably to the data base on global aurora and airglow intensity variations.